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Data assimilation for thermospheric Forecasting with application to satellite ephemeris prediction

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Jeffrey M. Forbes, Professor

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Climotological density patterns derived from low-orbit accelerometer data are shown to be consistent with meridional advection of disturbances originating at high latitudes. Long-term (11 year) and short-term (daily and 27-day) variations in thermospheric density are deliverated in terms of the MG II solar index.

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15. SUBJECT TERMS

Satellite drag, thermospheric density, accelerometer, ephemeris

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FORM A1-2
AUGMENTATION AWARDS FOR SCIENCE & ENGINEERING RESEARCH TRAINING (ASSERT) REPORTING FORM

The Department of Defense (DOD) requires certain information to evaluate the effectiveness of the AASERT program. By accepting this Grant Modification, which bestows the AASERT funds, the Grantee agrees to provide the information requested below to the Government's technical point of contact by each annual anniversary of the ASSERT award date.

1. Grantee identification data: *(R & T and Grant numbers found on Page 1 of Grant)*

   a. THE REGENTS OF THE UNIVERSITY OF COLORADO
   University Name

   b. F49620-97-1-0447
   Grant Number

   c. Not known
   PR Number

   d. Jeffrey Forbes,
   P.I. Name

   e. From: 1 Sept. 97 To: 31 Aug. 01
   AASERT Reporting Period

NOTE: Grant to which AASERT award is attached is referred to hereafter as "Parent Agreement."

2. Total funding of the Parent Agreement and the number of full-time equivalent graduate students (FTEGS) supported by the Parent Agreement during the 12-month period **prior to** the AASERT award date.

   a. Funding: $ 205,000

   b. Number FTEGS: 0.5

3. Total funding of the Parent Agreement and the number of FTEGS supported by the Parent Agreement during the current 12-month reporting period.

   a. Funding: $ 0

   b. Number FTEGS: 0

4. Total AASERT funding and the number of FTEGS and undergraduate students (UGS) supported by AASERT funds during the current 12-month reporting period.

   a. Funding: $ 13,200

   b. Number FTEGS: 1

   c. Number UGS: 0

VERIFICATION STATEMENT: I hereby verify that all students supported by the AASERT award are U.S. citizens.

Principal Investigator

Date

GRANT NUMBER: N00014-97-1-0766

FINAL REPORT

AASERT97 - Data Assimilation for Thermospheric Density Forecasting, with Application to Satellite Ephemeris Prediction
F49620-97-1-0447

Jeffrey M. Forbes, Principal Investigator
University of Colorado

1 Sept 01

Objectives: The research seeks to (1) better understand, specify and forecast the global structure of upper atmosphere density, and other parameters, through assimilation of observational data (mostly satellite drag) into models; and (2) improve upon existing capabilities to predict satellite orbits.

Summary of Findings: During the first two years of support, Mr. Rhoden extracted the geomagnetic density variation in low earth orbit from satellite accelerometer measurements, and showed how the climatological patterns are consistent with meridional advection of disturbances originating at high latitudes. He also delineated both the long-term (11-year) and short-term (daily and 27-day) variations in thermospheric density in terms of the Mg II solar index. Both of these results will play an important role in the development of future empirical models of atmospheric drag.

During the past year, and ongoing, Mr. Rhoden has expanded the earlier analysis to include comparisons with Jacchia 1970 (J70) model density trends in addition to the published MSISE-90 comparisons. He has also incorporated a short-term least squares fit analysis into those codes in order to develop an overall least squares model of the combined long- and short-term solar variabilities in the SETA density residuals. In addition, Mr. Rhoden has collected and preprocessed satellite data for approximately 20 satellites, including observations and element sets. This data is used in conjunction with special perturbation codes (SPDC and SPEPH) and the generation of satellite reference and predicted orbits necessary in the analysis of improvements in orbit prediction accuracies. These orbit prediction techniques are consistent with those used by USSPACECOM and AF/SWC. In fulfillment of University of Colorado requirements for the Ph.D. program, Mr. Rhoden's dissertation committee was formed and a comprehensive proposal was presented to his committee detailing future proposed activities and desired goals for his research project.

Personnel: This grant supported in part the PhD. Dissertation research of Mr. Eric Rhoden, Ph.D. Candidate in the Department of Aerospace Engineering Sciences. Mr. Rhoden is still in the process of completing his Dissertation requirement.

Publications: Rhoden, E.A., J.M. Forbes, and F.A. Marcos, The influences of geomagnetic and solar variabilities on lower thermosphere density, J. Atmos. Solar-Terr. Phys., 62, 999-1013, 2000.

Interactions/Transitions (Papers presented by Mr. Rhoden):

Poster presentation -- AFOSR Meeting, March 1999, Data Assimilation for Thermospheric Density Forecasting, with Application to SatelliteEphemeris Prediction (F49620-97-1-0447), Jeffrey M. Forbes and Eric A. Rhoden, University of Colorado, Boulder, CO.

Poster presentation -- 1999 Spring AGU, June 1999, Geomagnetic and Solar Variabilities in Thermospheric Density, E.A. Rhoden (1), J.M. Forbes (1), F.A. Marcos (2); (1) University of Colorado, Boulder, CO; (2) Air Force Research Laboratory, Hanscom AFB, MA.

Poster presentation -- 1999 CEDAR, June 1999, Geomagnetic and Solar Variabilities in Thermospheric Density, E.A. Rhoden (1), J.M. Forbes (1), F.A. Marcos (2); (1) University of Colorado, Boulder, CO; (2) Air Force Research Laboratory, Hanscom AFB, MA.

Comprehensive Exam Report and Presentation -- Improved Modeling ofThermospheric Density Perturbations with Application to Satellite Ephemeris Prediction, Eric Rhoden, December 2000.

Attended -- 1999 AAS/AIAA Astrodynamics Specialist Conference (attendee), August 16-18, 1999, Girdwood, AK.

New discoveries, inventions, patents: None

Honors/Awards: 3rd place, Best Student Poster Award, Annual CEDAR Meeting, Boulder, CO, June, 1999.